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(54) Title: RANDOM MICROEMBOSSED RECEPTOR MEDIA

(57) Abstract: A receptor medium with a sheet having a random microembossed imaging surface as one major surface thereof. The receptor medium can receive jettable materials, which include inks, adhesives, biological fluids, chemical assay reagents, particulate dispersions, waxes, electrically, thermally, or magnetically modifiable materials, and combinations thereof. The random microembossed medium unexpectedly solves such common inkjet printing problems as feathering, banding, and mudcracking in inkjet printing systems by controlling how an inkjet drop contacts and dries on an inkjet receptor medium and also Moire' effects. Clear lines of demarcation between adjoining colors of a pigmented inkjet image graphic can be obtained without creation of the Moire' effects. Methods of making and using the inkjet receptor medium are also disclosed.

Minnesota Mining and Manufacturing Company (3M) of St. Paul, MN markets GRAPHIC MAKER INKJET software useful in converting digital images from the Internet, ClipArt, or Digital Camera sources into signals to thermal inkjet printers to print such image graphics.

Inkjet inks are also commercially available from a number of multinational companies, particularly Minnesota Mining and Manufacturing Company which markets its Series 8551; 8552; 8553; and 8554 pigmented inkjet inks. The use of four process colors: cyan, magenta, yellow, and black (generally abbreviated "CMYK") permit the formation of as many as 256 colors or more in the digital image.

Media for inkjet printers are also undergoing accelerated development. Because inkjet imaging techniques have become vastly popular in commercial and consumer applications, the ability to use a personal computer to print a color image on paper or other receptor media has extended from dye-based inks to pigment-based inks. The media must accommodate that change. Pigment-based inks provide more durable images because of the large size of colorant as compared to dye molecules.

Inkjet printers have come into general use for wide-format electronic printing for applications such as engineering and architectural drawings. Because of the simplicity of operation and economy of inkjet printers, this image process holds a superior growth potential promise for the printing industry to produce wide format, image on demand, presentation quality graphics.

Therefore, the components of an inkjet system used for making graphics can be grouped into three major categories:

1. Computer; software, printer
2. Ink
3 Receptor medium

The computer, software, and printer will control the size, number and placement of the ink drops and will transport the receptor medium through the printer. The ink will contain the colorant which forms the image and carrier for that colorant. The receptor medium provides the repository which accepts and holds the ink. The quality of the inkjet image is a function of the total system. However, the compositions and interaction between the ink and receptor medium are most important in an inkjet system.

The disadvantage that many of these types of inkjet receptor media suffer for image graphics is that they comprise water-sensitive polymer layers. Even if subsequently overlaminated, they still contain a water-soluble or water-swellable layer. This water-sensitive layer can be subject over time to extraction with water and can lead to damage of the graphic and liftoff of the overlaminate. Additionally, some of the common constituents of these hydrophilic coatings contain water-soluble polymers not ideally suitable to the heat and UV exposures experienced in exterior environments, thus limiting their exterior durability. Finally, the drying rate after printing of these materials appears slow since until dry, the coating is plasticized or even partially dissolved by the ink solvents (mainly water) so that the image can be easily damaged and can be tacky before it is dry.

In recent years, increasing interest has been shown in microporous films as inkjet receptors to address some or all of the above disadvantages. Both Warner et al. and Waller et al. publications and Steelman et al. application identified above disclose microporous films to advantage. If the film is absorbent to the ink, after printing the ink absorbs into the film itself into the pores by capillary action and feels dry very quickly because the ink is away from the surface of the printed graphic. The film need not necessarily contain water-soluble or water-swellable polymers, so potentially could be heat and UV resistant and need not be subject to water damage.

Porous films are not necessarily receptive to water-based inkjet if the material is inherently hydrophobic and methods of making them hydrophilic have been exemplified for example by PCT Patent Publication No. WO 92/07899.

Other films are inherently aqueous ink absorptive because of the film material, for example, Teslin™ (a silica-filled polyolefin microporous film) available from PPG Industries and of the type exemplified in U.S. Patent No. 4,861,644. Possible issues with this type of material are that if used with dye based inks image density can be low depending on how much of the colorant remains inside the pores after drying. One way of avoiding this is to fuse the film following printing as exemplified in PCT Patent Publication No. WO 92/07899.

However, if dots are too large, then edge acuity is lost. Edge acuity is a reason for increased dpi image precision. Ability to control dot diameter is therefore an important property in an inkjet receptor medium.

Finally, the use of pigmented inks has raised additional issues in print quality, most notably "mudcracking". Mudcracking is the term used to describe the observation that swellable receptor coatings take up pigments by filtration of the particles at the surface and swelling to accommodate the carrier solvents, followed by drying, when the pigment particle film cracks as swelling goes down. The image appears as fragmented as a dried lake bed, with its mud cracked.

Summary of Invention

This invention has utility for the production of image graphics using inkjet printers. This invention unexpectedly solves such common inkjet printing problems as feathering, banding, and mudcracking in inkjet printing systems by controlling how an inkjet drop contacts and dries on an inkjet receptor medium.

Coassigned, PCT Patent Publication No. WO 99/55537 (Ylitalo et al.) discloses the use of regular microembossed surface patterns as one solution to the problems in the art.

Regular, engineered microembossed surface patterns could have a number of potential disadvantages as well. One could be the existence of Moire' patterns, particularly in raster printing operations where a scanning head traverses the microembossed sheet to dispense ink droplets at regular intervals. Another could be the time and expense involved with using the high precision machines needed to produce the master patterns.

One aspect of the present invention is the use of some random microembossed surfaces which can give good to excellent results with desktop and large format inkjet printing of image graphics. Further, the use of these random surface patterns can give some advantages over the prior art, including lack of Moire' effects, higher tolerance of cosmetic defects, and potentially lower costs of tool generation.

One aspect of the invention is a receptor medium comprising a sheet having a random microembossed surface topography as one major surface thereof, wherein the

Preferably, the receptor medium is an inkjet receptor medium.

More preferably, the microembossed imaging surface comprises cavities enclosed by walls, packed closely together, and with cavity volume commensurate with at least 100 percent ink from the targeted printer.

Another aspect of the present invention is an imaged inkjet receptor medium comprising a sheet having microembossed image surface and particles of pigment or dye dried on the microembossed image surface.

Another aspect of the invention is a method of making an inkjet receptor medium, comprising the steps of: (a) selecting a microembossing mold with a molding surface having a microembossed, but random, topography; and (b) contacting the molding surface of the mold against a polymeric sheet to form a random microembossed surface topography on the sheet wherein said topography is the inverse of the molding surface. Preferably, heat and pressure are used during the contacting step to form the microembossed surface.

Another aspect of the invention is a method of making an inkjet receptor medium, comprising the steps of: (a) selecting a microembossing mold with a molding surface having a microembossed, random topography; and (b) extruding a polymer over the molding surface of the mold to form a polymeric sheet having a random microembossed surface topography which is the inverse of the molding surface.

Another aspect of the invention is a method of making an inkjet receptor medium comprising the steps of: (a) selecting a microembossing mold with a molding surface having a microembossed, random topography; (b) contacting a fluid with the molding surface; and (c) solidifying the fluid to form a sheet having a random microembossed surface topography which is the inverse of the molding surface. Preferably, the fluid is a radiation-curable fluid and the fluid is solidified by exposing the fluid to UV, visible or electron beam radiation.

Another feature of the invention is the ability to microemboss an inkjet receptor medium with a random collection of microembossed surfaces.

An advantage of the invention is the minimization of common inkjet printing problems, such as banding, feathering, bleeding, and mudcracking, by altering the

At the left side of Figure 1a, one sees an inkjet drop 20, typically ranging in size from about 10 to about 150, and preferably from about 20 to about 140 pL, approaching microembossed image surface 12.

In the middle of Figure 1a, one sees an inkjet drop 30 within one cavity 14 as drop 30 begins to dry, cure, or otherwise coalesce, depending on the nature of the inkjet ink formulation.

On the right of Figure 1a, one sees an inkjet drop 40 that has dried and residing within a cavity 14 such that it is protected from abrasion from items contacting the multiplicity of peaks 16 that, on a macroscopic level, constitute the outermost surface of medium 10.

Figure 1b shows a post pattern embodiment of the present invention 50. At the left side of Figure 1b, one sees an inkjet drop 60, typically ranging in size from about 10 to about 150, and preferably from about 20 to about 140 pL, approaching embossed image surface 52.

In the middle of Figure 1b, one sees ink 70 on such surface 52 as drop 30 begins to dry, cure, or otherwise coalesce, depending on the nature of the inkjet ink formulation.

On the right of Figure 1b, one sees ink 80 that has dried about a post 54 such that it is protected from abrasion from items contacting the multiplicity of posts 54 that, on a macroscopic level, constitute the outermost surface of medium 50.

Figure 1a also illustrates an important consideration of the invention: more than one drop of ink can reside in a single cavity, because mixing of the colors: cyan, yellow, and magenta are needed to create the infinite number of colors now demanded in inkjet printing. Thus, one could size the volume of cavities to anticipate the placement of as many as three drops of different colors in order to satisfy multi-color printing. The volume of a cavity should preferably be at least 10, and more preferably at least 30 pL. The volume of a cavity can range from about 20 to about 1,000, and preferably from about 60 to about 600 pL.

The designed volume of the cavities depends on the desired shape of the cavities and the printed ink drop volume. While the illustration of Figure 1a shows curvilinear slopes to the bottom of a cavity 14 between adjacent peaks 16, a variety of embossing geometries can be chosen within the scope of the invention.

Polymeric Film

The polymeric sheet used in the inkjet medium can be made from any polymer capable of being microembossed in the manner of the present invention. The sheet can be a solid film. The sheet can be transparent, translucent, or opaque, depending on desired usage. The sheet can be clear or tinted, depending on desired usage. The sheet can be optically transmissive, optically reflective, or optically retroreflective, depending on desired usage.

Nonlimiting examples of polymeric films include thermoplastics, such as polyolefins, poly(vinyl chloride), copolymers of ethylene with vinyl acetate or vinyl alcohol, polycarbonate, norbornene copolymers, fluorinated thermoplastics such as copolymers and terpolymers of hexafluoropropylene and surface modified versions thereof, poly(ethylene terephthalate), and copolymers thereof, polyurethanes, polyimides, acrylics, plasticized polyvinyl alcohols, blends of polyvinylpyrrolidone and ethylene acrylic acid copolymer (Primacor™ , The Dow Chemical Company) and filled versions of the above using fillers such as silicates, aluminates, feldspar, talc, calcium carbonate, titanium dioxide, and the like. Also useful in the application are non-wovens, coextruded films, and laminated films made from the materials listed above.

More specifically, polyolefins can be ethylene homopolymers or copolymers, such as 7C50 brand ethylene propylene copolymer commercially available from Union Carbide Co. of Houston, TX. Other specifically useful films include LEXAN polycarbonate from General Electric Plastics of Pittsfield, MA, ZEONEX polymer from B. F. Goodrich of Richfield, OH, THV-500 polymer from Dyneon LLC of Oakdale, MN, plasticized poly(vinyl chloride), poly(ethylene terephthalate) copolymer, EASTAR 6763, from Eastman, AFFINITY PL 1845 from Dow Chemical Company, plasticized polyvinyl alcohols, ECOMATY AX 50 and AX 2000, from Nippon Gohsei, and SURLYN acrylic acid copolymers from DuPont DeNemours and Co. of Wilmington, DE.

Properties of polymeric sheets of the present invention can be augmented with outer coatings that improve control of the ink receptivity of the microembossed image surface 12 of the ink receptor medium 10. As stated in the Background of the Invention above, any number of coatings are known to those skilled in the art. It is possible to employ any of these coatings in combination with the microembossed image surface of the

mordant may be coated onto the microembossed surface in order to demobilize or "fix" the dyes. Mordants which may be used generally consist of, but are not limited to, those found in patents such as U.S. Patent Nos. 4,500,631; 5,342,688; 5,354,813; 5,589,269; and 5,712,027. Various blends of these materials with other coating materials listed herein are also within the scope of the invention.

Additionally, directly affecting the substrate by means generally known in the art may be employed in the context of this invention. For example, polypropylene could be corona treated before or after microembossing, or poly(vinyl chloride) could be surface dehydrochlorinated before or after microembossing, and either of these films could be used as a printable substrate.

Optional Adhesive Layer and Optional Release Liner

The receptor medium 10 optionally has an adhesive layer on the major surface of the sheet opposite microembossed image surface 12 that is also optionally but preferably protected by a release liner. After imaging, the receptor medium 10 can be adhered to a horizontal or vertical, interior or exterior surface to warn, educate, entertain, advertise, etc.

The choice of adhesive and release liner depends on usage desired for the image graphic.

Pressure-sensitive adhesives can be any conventional pressure-sensitive adhesive that adheres to both the polymer sheet and to the surface of the item upon which the inkjet receptor medium having the permanent, precise image is destined to be placed. Pressure-sensitive adhesives are generally described in Satas, Ed., Handbook of Pressure Sensitive Adhesives, 2nd Ed. (Von Nostrand Reinhold 1989). Pressure-sensitive adhesives are commercially available from a number of sources. Particularly preferred are acrylate pressure-sensitive adhesives commercially available from Minnesota Mining and Manufacturing Company and generally described in U.S. Patent Nos. 5,141,790; 4,605,592; 5,045,386;and 5,229,207; and EPO Patent Publication No. EP 0 570 515 B1 (Steelman et al.).

Release liners are also well known and commercially available from a number of sources. Nonlimiting examples of release liners include silicone coated kraft paper, silicone coated polyethylene coated paper, silicone coated or non-coated polymeric

which itself carries the inverse of the pattern which is to be microembossed on the thermoplastic sheet.

Compressing Method

This method uses a hot press familiar to those skilled in the art of compression molding.

The pressure exerted in the press typically ranges from about 4.1×10^4 to about 1.38×10^5 kPa, and preferably from about 6.9×10^4 to about 1.0×10^5 kPa.

The temperature of the press at the mold surface typically ranges from about 100 °C to about 200 °C, and preferably from about 110 °C to about 150 °C.

The dwell time of pressure and temperature in the press typically ranges from about 1 to about 5 minutes. The pressure, temperature and dwell time used depend primarily on the particular material being microembossed, as is well known to those skilled in the art. The process conditions should be sufficient to cause the material to flow and faithfully take the shape of the surface of the tool being used. Any generally available commercial hot press may be used, such as Wabash Model 20-122TM2WCB press from Wabash MPI of Wabash, IN.

Extrusion Method

A typical extrusion process for the present invention involves passing an extruded substrate through a nip created by a chilled roll and a casting roll having a surface having a random pattern inverse of desired microembossed image surface, with the two rolls rotating in opposite directions. A flexible sheet or belt comprising the tool may also be used and put through the nip simultaneously with the melt.

Single screw or twin screw extruders can be used. Conditions are chosen to meet the general requirements which are understood to the skilled artisan. Representative but non-limiting conditions are outlined below.

The temperature profile in the extruder can range from 100 °C to 250 °C depending on the melt characteristics of the resin.

The temperature at the die ranges from 150 °C to 230 °C depending on the melt strength of the resin.

and chemical properties is known to those skilled in the art. Commercial suppliers of such materials include Henkel (Amber, PA), Sartomer (Exton, PA), UCB (Smyrna, GA), and Ciba-Geigy (Hawthorne, NY).

Usefulness of the Invention

Inkjet receptor media of the present invention can be employed in any environment where inkjet images are desired to be precise, stable, rapid drying, and abrasion resistant.

Inkjet receptor media of the present invention can accept a variety of inkjet ink formulations to produce rapid drying and precise inkjet images. The topography of the microembossed image surface of the inkjet receptor medium can be varied for optimum results, depending on several factors, such as: ink droplet volume; ink liquid carrier composition; ink type (pigment or blend of pigment and aqueous or non-aqueous dye); and manufacturing technique (machine speed, resolution, roller configuration); etc.

The imaging surface of the present invention has been found to control dot location to remain within isolated cavities 14 of surface 12 and around posts.

For example, a test pattern of 3 overlapping circles of primary colors (cyan, magenta, yellow), secondary colors (red, green, blue) and tertiary color (black) inkjet ink printed onto an inkjet receptor medium of the present invention shows the precision of color control and pigment location on the medium.

Further, because the pigment particles reside beneath the nominal macroscopic surface of the inkjet receptor medium, the pigment particles are protected from abrasion that does not penetrate as deep as the location of the particles. Incidental abrasion of the graphic during graphic handling after printing is minimized. Moreover, one could use a multilayered microembossed pattern in which the cavity walls and floors are made of substantially different materials, in order to manage coalescence of ink on cavity floors of media of the present invention.

The possibilities of image manipulation on the surface of an inkjet receptor medium, created by the topography of the image surface of that medium, are myriad to those skilled in the art, because the same pattern need not cover the entire surface of the medium. For example, different patterns could be employed, stepwise, in gradation, or

Media of the present invention can also be employed with non-jettable materials so long as an inkjet printing head is not needed to deposit the material on the embossed surface. For example, U.S. Patent No. 5,658,802 (Hayes et al.) discloses printed arrays for DNA, immunoassay reagents or the like using arrays of electromechanical dispensers to form extremely small drops of fluid and locate them precisely on substrate surfaces in miniature arrays.

The following examples further disclose embodiments of the invention.

General Information

Topography of both microembossed and smooth surfaces were examined by interferometry using a roughness/step tester such as those available from the Veeco Instruments of Plainview, NY, or alternatively were examined by scanning electron microscopy or optical microscopy where equipped for depth measurement (z-axis micrometer).

Desktop printers: Hewlett-Packard (HP)855 Cse (dye inks with pigmented black, drop size around 20 pL), using standard media (paper) printing mode at "normal" speed (vs. "better" and "presentation" speeds). HP2000 (dye inks with pigmented black, drop size around 20 pL), using "plain paper" mode at "normal" speed. Tektronix Phaser 300, 300 dpi, plain paper mode.

Wide format printers: Encad NOVAJET 4, Minnesota Mining and Manufacturing Company's pigmented inks (pigment particles 100 - 200 nm and high surface tension; drop size 140 pL per dot per color), 4-pass mode; and Hewlett-Packard 2500CP, HP pigmented inks (drop size 20 pL), Opaque Vinyl mode, 8 pass mode.

Test patterns: Desktop prints were made using "TEST PATTERN 1", a standard Minnesota Mining and Manufacturing Company print test. This test contains color blocks and color blocks with thin lines intersecting them. Wide format prints were made using "TEST PATTERN 2", a three circle pattern, where overlapping 2 inch diameter circles of cyan, magenta, and yellow create red, blue, green, and black; or "TEST PATTERN 3", a

Some of this material was subsequently flattened by compression molding against a smooth RTV silicone surface. This material will be referred to as CONTROL 1. Samples of SUBSTRATE 1 and CONTROL 1 were printed upon with several printers. SUBSTRATE 1 was also used further to make the same random hemispherical void pattern in other thermoplastics. A piece of SUBSTRATE 1 was used as a template to cast a curable silicone ("SILASTIC J" two part RTV silicone, obtained from Dow Corning Co. of Midland, MI) so as to form a crosslinked rubber sheet comprising the inverse topography of the random pattern on SUBSTRATE 1. This crosslinked sheet was then used in compression molding of SURLYN 1705 (ionomer resin, available from DuPont DeNemours and Co.) to form SUBSTRATE 2. A smooth sheet of SURLYN 1705 was used as CONTROL 2.

EXAMPLE 2 – Print tests of SUBSTRATE 1 and CONTROL 1

Printer: HP855Cse. Excellent image quality and resolution was observed when TEST PATTERN 1 was printed in plain paper mode at normal speed on SUBSTRATE 1. Qualitative comparison of CONTROL 1 to SUBSTRATE 1, showing the strong effect of print resolution using only the surface pattern (without further coatings, etc.) is exemplified in Figures 3 and 4, respectively.

Printer: HP2500CP. This printer, used to print the TEST PATTERN 3 test pattern, caused some ink bleed on SUBSTRATE 1 in areas of high color fill. Also, the dry time in the areas showing ink bleed was poor. Other than this, the quality of the print was very good, with good color density. SOLUTION 1 and SOLUTION 2 were coated onto two samples of SUBSTRATE 1 using a #3 Mayer rod; after drying, the coated substrates were subjected to the same print tests. No ink bleed was observed, and dry times were less than 5 minutes even in the high color fill areas. Also, image density was improved in both the coated samples compared to uncoated Substrate 1. Solution 1 renders the print water-resistant. Figures 5 and 6, respectively, illustrate the difference between prints on SUBSTRATE 1 with no coating vs. coating with SOLUTION 2.

The line width of the same line at the same point in the test print, on CONTROL 1, ranged from 100 to about 250 micrometers. Thus, use of random cavities on the surface of the substrate restricts spreading of the ink.

EXAMPLE 3 - Print Tests on SUBSTRATE 2 and CONTROL 2

HP2000. SUBSTRATE 2 and CONTROL 2 were used to print TEST PATTERN 1 in plain paper mode/normal quality. Figures 13 and 14, respectively, show the difference in the prints obtained. In general, the observations for SUBSTRATE 2 vs. CONTROL 2 were the same as those made for SUBSTRATE 1 vs. CONTROL 1.

EXAMPLE 4 – Generation of SUBSTRATE 3

A holographic diffuser was generated according to US Patent No. 5,534,386 (Physical Optics Corporation), and a nickel electroform was made. This surface diffuser pattern was replicated using the procedures of U.S. Patent No. 5,175,030, and a UV cured resin composed of RDX51027 (UCB of Smyrna, GA)/BR-31 (Dia-Ichi Kogyo Sayaku of Kyoto, Japan)/methyl styrene (Sigma-Aldrich of Milwaukee, WI)/phenoxyethyl acrylate (Henkel of Ambler, PA)/EBECRYL 220 (UCB)/FC 430 (Minnesota Mining and Manufacturing Company)/LUCERIN TPO (BASF of Wyandotte, MI) in the ratio of 55/22/11/6.5/5.5/0.3/3), and using MELINEX 617 (ICI of Wilmington, DE) polyester as substrate.

EXAMPLE 5 – Print tests on SUBSTRATE 3

HP855Cse, HP2500CP. SUBSTRATE 3 allowed for greater movement of wet ink than SUBSTRATE 1 or SUBSTRATE 2. This problem was most noticeable when the HP2500CP was used to make the TEST PATTERN 2 pattern, probably due to the larger total volume of ink per dot delivered from the wide format printer.

However, when SOLUTION 1 was added, SUBSTRATE 3 exhibited outstanding appearance. The colors were extremely intense. The backlit properties of the print were also excellent. Intense color was seen both from the back and front of the substrate, as the sample became quite transparent where the ink was deposited. Figure 15 shows some aspects of the appearance of the test print.

The following examples demonstrate the use of several randomly microembossed inkjet receptors.

EXAMPLE 7

A 20 percent solids solution containing by weight 85 percent of a 70:30 blend of polyvinylpyrrolidone (PVP K90, available from ISP) and poly(ethylene-co-acrylic acid) (available as an aqueous dispersion (Michem Prime 4983R) from Michelman) and 15 percent Pycal 94 (available from ICI surfactants, Wilmington, DE) was prepared. This ink receptor composition was coated at approximately 5.7 mils wet thickness onto 3.88 mil PET (polyethylene terephthalate) film primed with PVDC (polyvinylidene chloride) and dried to give a clear film with a dry coating thickness of approximately 29 micrometers. This film was subsequently coated with a 3 percent solids solution containing a 1:1 blend of Methocel K-35 (available from Dow Chemical Company) and Alumina (available as an aqueous dispersion (Dispal 23N4-20) from the Condea Vista Chemical Co.). The resulting dry thickness of this coating was approximately 1 micrometer. The coated surface of this film was microembossed by pressing it against a nickel plated copper tool in a compression molding apparatus (Wabash Model 20-122TM2WCB, available from Wabash MPI of Wabash, IN). The platen temperatures were 67 °C and a pressure of 4.3 Mpa was applied for 12 minutes.

The nickel plated copper microembossing tool used in this example contained two orthogonal series of grooves. In each series, the distance between adjacent grooves was about 154 micrometers, and the depth of the grooves was either 26 micrometers or 9 micrometers based on a mathematical algorithm dependent on the depths of the preceding grooves. The specific probabilities used in the algorithm are shown in Table 2.

Table 2. Probabilities used to determine groove depth.

Wall (I-2)	X	X	X	Tall	Small
Wall (I-1)	Tall	Small	Tall	Small	Small
Wall (I)	Tall	Tall	Small	Small	Small
P%(Small)	100 %	75 %	50 %	25 %	0 %

grooves. For deep grooves spaced more than 370 micrometers apart, there are two shallow (9 micrometer depth) grooves which equally subdivide the space between the deep grooves. The shallow grooves were about 9 micrometers wide at the bottom and about 12 micrometers wide at the top.

The microembossed surface of this film was imaged and analyzed using the procedure described in Example 7. The data are shown in Table 3.

EXAMPLE 9

An additional sample of the coated PET film whose preparation is described in Example 7 was microembossed by pressing its coated surface against a nickel plated copper tool in a compression molding apparatus (Wabash Model 20-122TM2WCB, available from Wabash MPI of Wabash, IN). The platen temperatures were 67 °C and a pressure of about 4.3 Mpa was applied for about 11 minutes.

The nickel plated copper microembossing tool used in this example contained two orthogonal series of grooves. In each series, the primary grooves are 26 micrometers deep and the remainder are 9 micrometers deep. The center-to-center distance between adjacent deep grooves varies in an irregular way between a lower limit of about 370 micrometers and an upper limit of 470 micrometers. Over the entire series, the distribution in the deep groove spacing is characterized very well by a nearly uniform probability distribution. The deep grooves were about 9 micrometers wide at the bottom and 14 micrometers wide at the top. Between each of the deep grooves, there exist two shallow (9 micrometer depth) grooves that equally subdivide the space between the two deep grooves. The shallow grooves were about 9 micrometers wide at the bottom and about 12 micrometers wide at the top.

The microembossed surface of this film was imaged and analyzed using the procedure described in Example 7. The data are shown in Table 3.

terephthalate) film primed with PVDC (polyvinylidene chloride) (available from the Minnesota Mining and Manufacturing Company) and dried in a single zone oven system at 140 °C, to give a clear film with a dry coating thickness of approximately 53 micrometers.

The microembossed surface of the SILASTIC J microembossing tool was then pressed into the coated side of the ink receptive sheet in a compression molding apparatus. The temperature of the platens was 170 °C and a pressure of about 1.6 MPa was applied for about five minutes. The pressure was applied for an additional 5 - 10 minutes while the platens were cooled to about 100 °C. The platens were then opened and the microembossed ink receptive film was removed from the microembossing tool.

The microembossed surface of a commercial, nominally planar inkjet receptor film, CG3460, obtained from Minnesota Mining and Manufacturing Company, was imaged and analyzed using the procedure described in Example 7 using the printers and printer settings below:

Hewlett-Packard HP 890C, transparency mode, best quality, color automatic.

Hewlett-Packard HP 2000C, rapid dry transparency mode, best quality, color automatic.

The data are shown in Table 4 below where "C", "M", "Y", "R", "G", "B", and "K" represent cyan, magenta, yellow, red, green, blue, and black densities, respectively.

Table 4.

890C	C	M	Y	R	G	B	K
Example 10	1.52	1.41	0.95	1.19, 0.82	1.06, 0.71	1.50, 0.60	1.65
3M3420	1.59	1.47	0.88	1.12, 0.85	1.04, 0.68	1.44, 0.62	1.68
2000C							
Example 10	2.10	1.07	1.91	1.02, 1.85	1.20, 1.52	1.37, 0.61	1.67
3M3420	2.37	1.15	1.80	1.01, 1.96	1.37, 1.56	1.54, 0.68	2.52

An indication of ink dry times was measured in the following manner: Xerographic bond paper was placed on the imaged area 30 seconds after printing and rolled with a 5 pound roller. Table 5 below shows reflective image densities measured off the paper from transferred ink.

adjacent deep grooves varies in an irregular way between a lower limit of about 270 micrometers and an upper limit of about 470 micrometers. Over the entire series, the distribution in the deep groove spacing is characterized very well by a nearly uniform probability distribution. The deep grooves were about 9 micrometers wide at the bottom and 14 micrometers wide at the top. Between each of the deep grooves, there exist a number of shallow (9 micrometer depth) grooves. For deep grooves spaced less than 370 micrometers apart, there is one shallow groove at the midpoint between the two surrounding deep grooves. For deep grooves spaced more than 370 micrometers apart, there are two shallow (9 micrometer depth) grooves which equally subdivide the space between the deep grooves. The shallow grooves were about 9 micrometers wide at the bottom and about 12 micrometers wide at the top.

A smooth resin-coated control was also produced using a knotch-bar coater set to make a 1.5 mil thick coating. The UV curable resin was cast between a sheet of plain 5 mil PET film (Minnesota Mining and Manufacturing Company) and a sheet of MELINEX 617. The resin was cured by irradiation through the MELINEX using a MetalBox medium pressure mercury lamp on its high setting at a speed of 11.3 m/min. The plain PET was then separated leaving the MELINEX film with a smooth resin coating.

The microembossed film and the smooth sample were printed with cyan, magenta, yellow, red, green, blue, and black color blocks on a Hewlett-Packard HP2500 desktop printer using "HP premium transparency" mode, "best" quality, and "automatic" color settings with the standard inks supplied by Hewlett-Packard Corporation. The printed microembossed film looked sharp and uniform while the smooth sample looked mottled and non-uniform. The dry time was measured by placing a piece of paper over the print 30 seconds after the print was removed from the printer and rolling with a roller. The reflective image densities were then read using a Gretag SPM55 densitometer. These results are shown in Table 6 below.

What is claimed is:

1. A receptor medium comprising a sheet having a random, microembossed surface topography on one major surface thereof, wherein the sheet is nonporous.

2. The receptor medium of claim 1, wherein the random microembossed surface topography comprises cavities.

3. The receptor medium of claim 1, wherein the random microembossed surface topography comprises posts.

4. The receptor medium of claim 1, wherein the random microembossed surface topography is a microembossed pattern.

5. The receptor medium of claim 2, wherein each cavity of the random, microembossed surface topography has a capacity of at least about 10 pL.

6. The receptor medium of claim 5, wherein cavities are enclosed by walls and packed closely together such that thickness of the wall tops is minimized.

7. The receptor medium of claim 1, wherein the random microembossed surface topography has a topography to protect printed material from abrasion from items contacting the embossed surface, that on a macroscopic level, constitutes the outermost surface of the medium.

8. The receptor medium of claim 2, wherein the random microembossed surface topography comprises a random collection of cavities wherein volume of any one cavity is sufficient enough to anticipate placement of at least two drops of ink.

9. The receptor medium of claim 2, wherein the capacity is for at least three drops of ink.

17. The receptor medium of claim 1, wherein the sheet comprises one or more layers.

18. The receptor medium of claim 1, further comprising an adhesive layer on a major surface opposite the microembossed surface.

19. The receptor medium of claim 18, further comprising a release liner protecting the adhesive layer.

20. A random microembossed receptor medium comprising the receptor medium of claim 1 and a material deposited on the microembossed surface.

21. The receptor medium of claim 20, wherein the material is jettable.

22. The receptor medium of claim 21, wherein the jettable material is selected from the group comprising inks, adhesives, biological fluids, pharmaceuticals, chemical assay reagents, particulate dispersions, waxes, electrically, thermally, or magnetically modifiable materials, and combinations thereof.

23. The receptor medium of claim 21, wherein the jettable material is a dye based ink.

24. The receptor medium of claim 21, wherein the jettable material is a pigmented ink.

25. The receptor medium of claim 24, wherein the pigmented ink comprises particles of pigment that reside in cavities of the microembossed surface.

26. A method of making a receptor medium, comprising steps of:

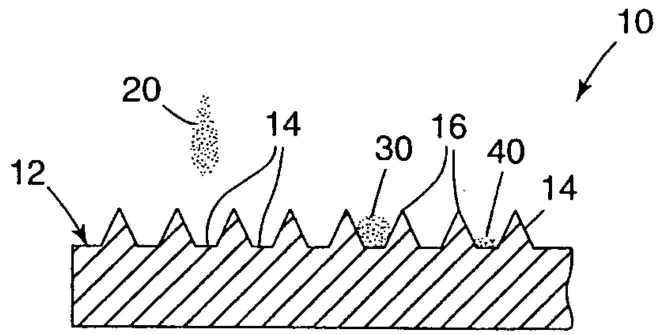

Fig. 1A

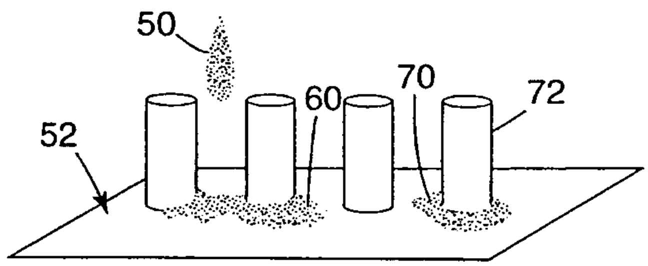

Fig. 1B

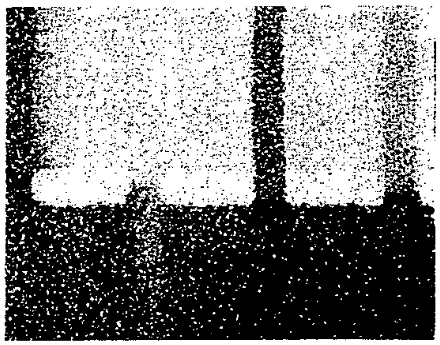

Fig. 5

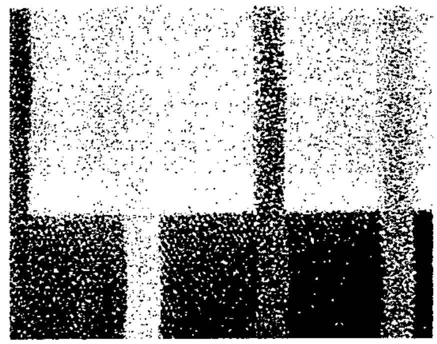

Fig. 6

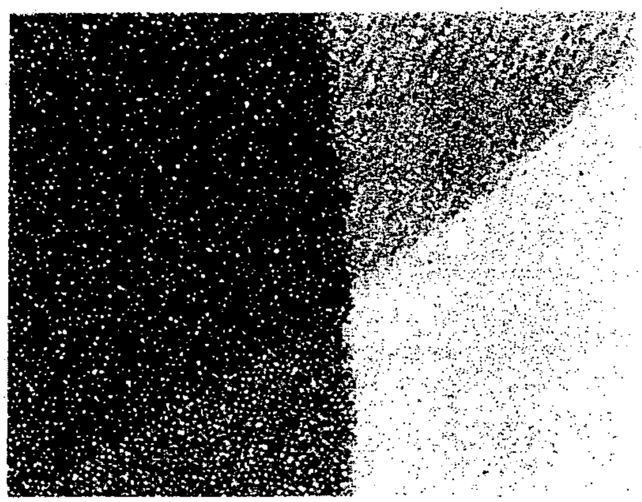

Fig. 7

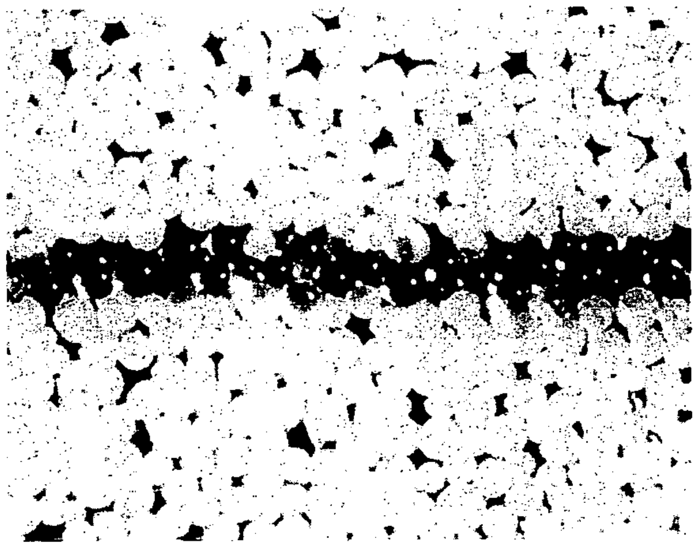

Fig. 11

Fig. 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/14994

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B41M5/00 B41M3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B41M G03G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 336 (M-535), 14 November 1986 (1986-11-14) & JP 61 141585 A (CANON INC), 28 June 1986 (1986-06-28) abstract	1,24,27
A	EP 0 832 756 A (EASTMAN KODAK CO) 1 April 1998 (1998-04-01) page 2, line 48 -page 3, line 8 example 1	1,24,27
A	EP 0 544 283 A (EASTMAN KODAK CO) 2 June 1993 (1993-06-02) page 2, line 51 -page 3, line 42 examples	1,24,27

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 August 2000	24/08/2000

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/14994

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